# Trends in Wildland Fire

Over millennia, fire has played an integral role in regulating the spatial pattern, composition, and structure of California's natural resources. With its Mediterranean climate, productive soils, and frequent ignitions from lightning and Native American peoples, fire has been an endemic force shaping the landscapes of the State. Many areas of the State have evolved under the natural selection pressure of frequent and relatively low intensity fires (Weaver, 1943). Other areas have been subjected to less frequent but higher intensity fires. From coastal grasslands to sub-alpine forests to the Mojave Desert, fire has been an active ecological agent in almost all vegetated areas.

The pre-settlement period (prior to 1700) was dominated by fire regimes that were a result of ignitions from both lightning and indigenous people. As is common for indigenous peoples throughout the world, California's Native Americans also set fire to alter plant and animal populations, facilitate the collection of desirable species, and protect their villages from damage from uncontrolled fire. While significant variation in fire likely followed changes in broad-scale shifts in climate, the thousands of years of occupation by Native Americans must be considered as sufficiently long to have been an evolutionary force supplementing and altering the long-term selective pressure from lightning fires. Consequently, the pre-settlement period is often viewed as the period under which the "natural" fire regime standard for assessing the ecological role of fire developed.

*Near Donner Lake, Nevada County, California 1888, following logging operations.*

Beginning first with the Spanish missionaries, then with trappers and miners, and finally with westward expansion offered by the railroads, the settlement period produced significant changes to land use. Livestock grazing, water and timber utilization, farming and mining, and other anthropogenic activities altered vegetation and brought new ignition sources. Alterations of fire regimes from the settlement period greatly accelerated after the discovery of gold in the mid-19$^{th}$ century, with a large influx of settlers dramatically altering the landscape (Leiberg, 1902). The nature of these changes can be seen in early photographs depicting settlement activities (Gruell, 2001).

Later, at the turn of the century and accelerating after the formation of the U.S. Forest Service (USFS) and the State's Division of Forestry, organized fire suppression came to define the modern-era of fire management in the State. Modern-era trends resulting from changes in land use, population growth and development, fire suppression, and variations in climate are all affecting how much fire occurs, what these fires are like, and how these fires interact with the natural environment. This section will address changes in the amount and nature of California's wildland fire over time and how these changes affect various natural and social resources.

## Pre-settlement fire regimes

***Fire regime refers to the pattern and variability of fire occurrence and its effect on vegetation.***

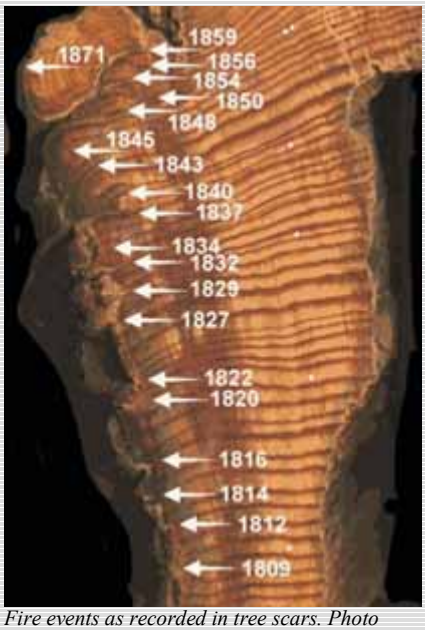
Although the pattern of fire occurrence and severity differed among the many vegetation types throughout California, it is well documented that much of the land burned frequently. Estimating the frequency of fire in an area of interest to determine its historical fire regime often involves calculating the fire return interval (FRI), a measure of the amount of time required to burn most or all of an area of interest, as based on individual records of fire events. Some areas burned on an almost annual basis. Other lands experienced less frequent and more severe fires, but fire still functioned as an important ecological force maintaining ecosystem vigor and ranges in habitat conditions. The net effect on vegetation is better characterized as fire-maintained, or fire-recycled, rather than fire-destroyed. In areas where the regime indicates high severity and stand-replacing types of fires, these fires often served as forces of renewal for plants and habitats that required fire to restore vegetation life cycles.

***During the pre-settlement period, roughly one-third of the State burned frequently (every 35 years or less).***

It is important to recognize the significant impact Native Americans played on fire regimes. The use of fire by Native Americans has been widely established to have strongly influenced how and when fires occurred over roughly the last 7,000 years prior to European occupation of California. Native Americans burned for a myriad of reasons ranging from vegetation manipulation for foodstuffs and materials to spiritual reasons. In some areas, such as coastal California, it appears that anthropogenic ignition sources likely dominated the fire regime (Lewis, 1980; Finney and Martin, 1989; Keeley, 2002).

**What are fire regimes?** Fire regime refers to the pattern and variability of fire occurrence and its effect on vegetation. It is usually expressed or classified based on both fire frequency and the general severity of fire effects on the dominant vegetative life forms present. Natural groupings for classifying fire regime are usually a composite of regional areas or climate zones, and some classification of the vegetation type in that area. Not surprisingly, different vegetation types may burn less or more frequently, and may have substantial ranges in severity as well. Depending on the level of detail in the classification, additional characteristics of the fire itself, such as seasonality, size, and intensity may also be included (Agee, 1993). Fire regime mapping techniques may also use terrain features such as slope or aspect to differentiate areas that may burn more or less frequently.

Much of the basis for inferring what pre-settlement era fire regimes were like relies on fire history studies. These records of fires are recorded for particular areas over particular periods. California has some of the most exhaustive and detailed fire history work done worldwide. Ethnographic records (Lewis, 1973; Anderson and Moratto, 1996), stand-structure and tree-ring analysis (Kilgore and Taylor, 1979; Bonnicksen and Stone, 1981; Finney and Martin, 1989; Swetnam, 1993; Brown and Baxter, 2002), and charcoal deposit analysis (Mensing et al., 1999) are common methods of documenting and measuring elements of fire regimes.



*Fire events as recorded in tree scars. Photo courtesy Tom Swetnam.*

On the right, the ponderosa pine cross-section shows 20 fire scars over the period of 1805 to 1871, or roughly a fire every four years. The frequent, low-intensity surface fires typical in this regime provided the types of low severity fire that maintained mixed conifer ecosystems as mixed-aged, mixed-size forests. Large trees are unaffected by the fire and most seedlings are killed. However, due to fuels and weather effects on fire behavior causing variability in space and time, some seedlings survive fires, grow, and are recruited into the overstory.

A simple Statewide fire regime classification system provides an approximate idea of range in fire frequency and severity, as it existed before European settlement. This classification, modified from the USFS's National Fire Plan Condition Class Assessment (Hardy et al., 2001), is highly generalized and can only illustrate coarse differences in fire regimes. However, the resulting analysis is appropriate given the statewide scale of inquiry, where broad differences in regimes point out significant implications for managing wildland fire at the regional scale (Hann and Bunnell, 2001).

The resulting Fire and Resource Assessment Program (FRAP) pre-settlement fire regime map uses a modified fire regime classification that combines three FRI classes (0 to 35 years, 35 to 100 years, more than 100 years) with three levels of fire severity (LOW: non-lethal; MIXED: partially-lethal; HIGH: stand-replacing, or fully-lethal). The underlying vegetation map uses the current California Wildlife Habitat Relationship (CWHR) habitat type vegetation classifications. Under the CWHR classification, human-modified types like urban or agriculture are considered non-wildland. Twenty percent of the State is currently either non-wildland (agriculture, urban, etc.) or non-vegetated lands (see Table 1). The remaining 80 percent of land area currently supporting wildlands can be categorized according to the following:

- Eighty-seven percent of the State's wildlands supported low or mixed severity fire regimes.
- Thirty-four percent supported FRIs of zero to 35 years, the vast majority of which (32 percent) was in the low severity, non-lethal class as typified by grasslands and ponderosa pine/mixed-conifer forest types (see Table 1).
- Thirty-three percent of the State-supported moderate FRIs are in the 35 to 100 year range, with 17 percent as mixed severity such as the sagebrush steppe of northeast California and 10 percent as fully-lethal regimes endemic to chaparral ecosystems.

*Area of low severity fire on the McNally Fire, July 2002. These fires are "non-lethal" and will not destroy the forest stand. Photo courtesy USFS.*

- The remaining one-third of the State's wildlands supported long FRIs of greater than 100 years, with the vast majority as partially-lethal severity fire regimes typical of the desert region.

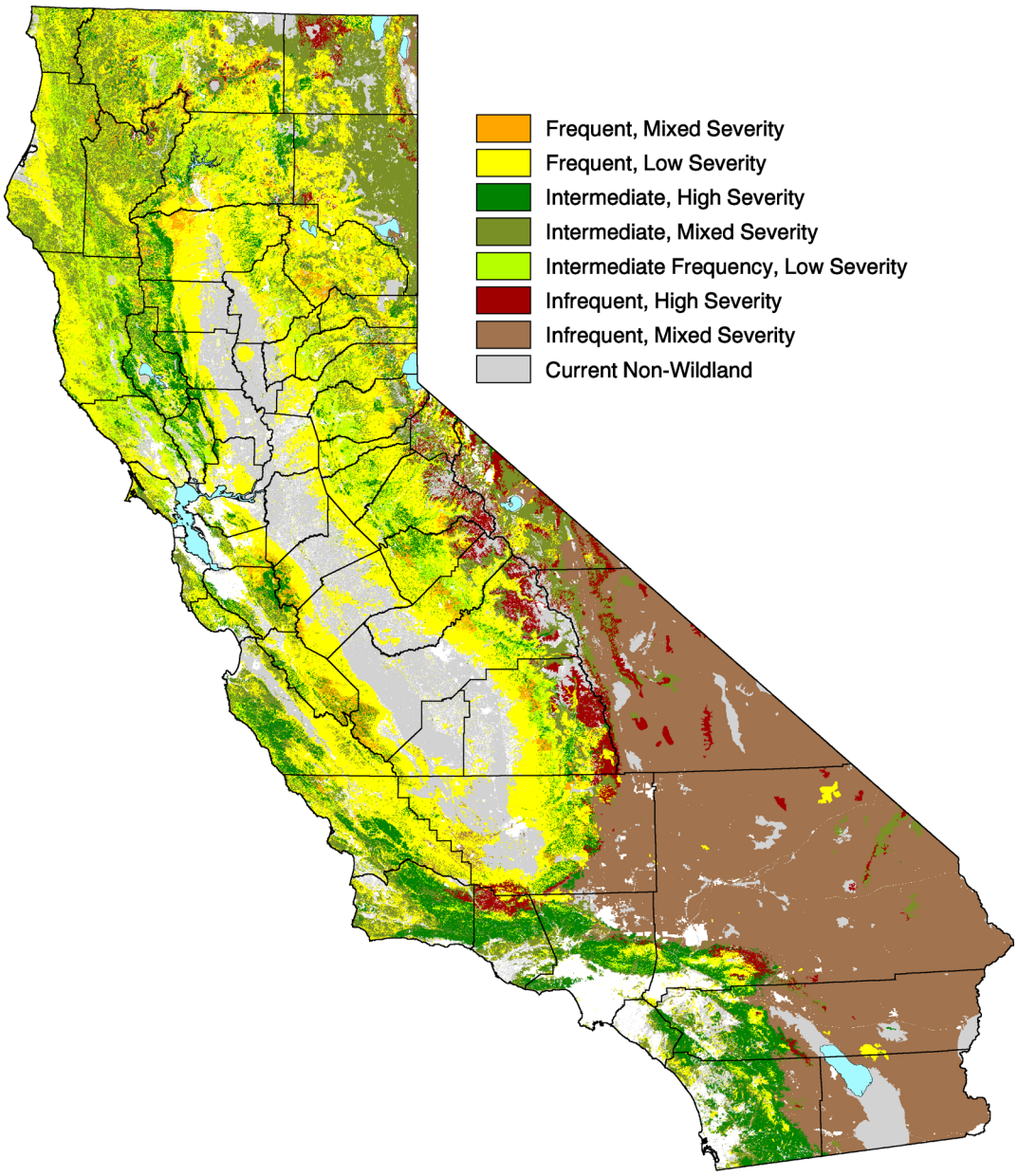
For complete information on natural fire regimes by bioregion and county, see Fire Data. Taken collectively, the picture of fire regimes shows the range in frequencies and severities common to California prior to European settlement. Under natural regimes, where many vegetation types burned frequently, the range in annual acres burned has been estimated between five and 13 million acres (Martin and Sapsis, 1992). While many high-frequency lands (e.g., the central valley grasslands) have been converted to non-wildlands and effectively removed from an assessment of natural regimes, roughly 70 percent of the remaining wildlands supported fire regimes with frequencies less than 100 years.

Table 1. Area of pre-settlement fire regimes in California based on current land cover, expressed in thousands of acres and as percentage of total Statewide wildland area

| | Severity | | | |
|---|---|---|---|---|
| **Frequency** | **High** | **Mixed** | **Low** | **Totals** |
| Frequent -- acres | -- | 1,800 | 25,920 | 27,720 |
| (< 35 years) % | 0 | 2 | 32 | 34 |
| Intermediate -- acres | 8,270 | 13,230 | 4,480 | 25,980 |
| (35 – 100 years) % | 10 | 17 | 6 | 33 |
| Infrequent -- acres | 2,810 | 23,760 | -- | 26,570 |
| (>100 years) % | 3 | 30 | 0 | 33 |
| Non-wildland | | | | (20,640) |
| Totals -- acres | 11,080 | 38,790 | 30,400 | 100,910 |
| % | 13 | 49 | 38 | 100 |

*Source: FRAP, 2003a*

Figure 1. Pre-European settlement fire regimes of California




*Source: FRAP, 2003a*

## Findings on modern-era fire trends

*Pines Fire, east of Julian, San Diego County, California. Date of fire origin: July 29, 2002. CDF photo.*

In contrast to pre-settlement fire regimes, where in any given year millions of acres would burn, the modern-era results in an average of approximately 250,000 acres, or 0.3 percent of California's wildlands, burning annually. This large reduction is due to two main changes: 1) many lands have been developed and changed from wildland vegetation fuels to highly modified systems that render them non- or marginally-flammable; and 2) the extensive fire protection services offered by local, State, and federal authorities that actively suppress fires. Much of the land use change has been the result of urbanization and intensive agriculture that broke up patches of vegetation fuels and increased accessibility for firefighters. Previously, the majority of these lands supported frequent fires. A prime example of this pattern exists with the grasslands that previously dominated the central valley.

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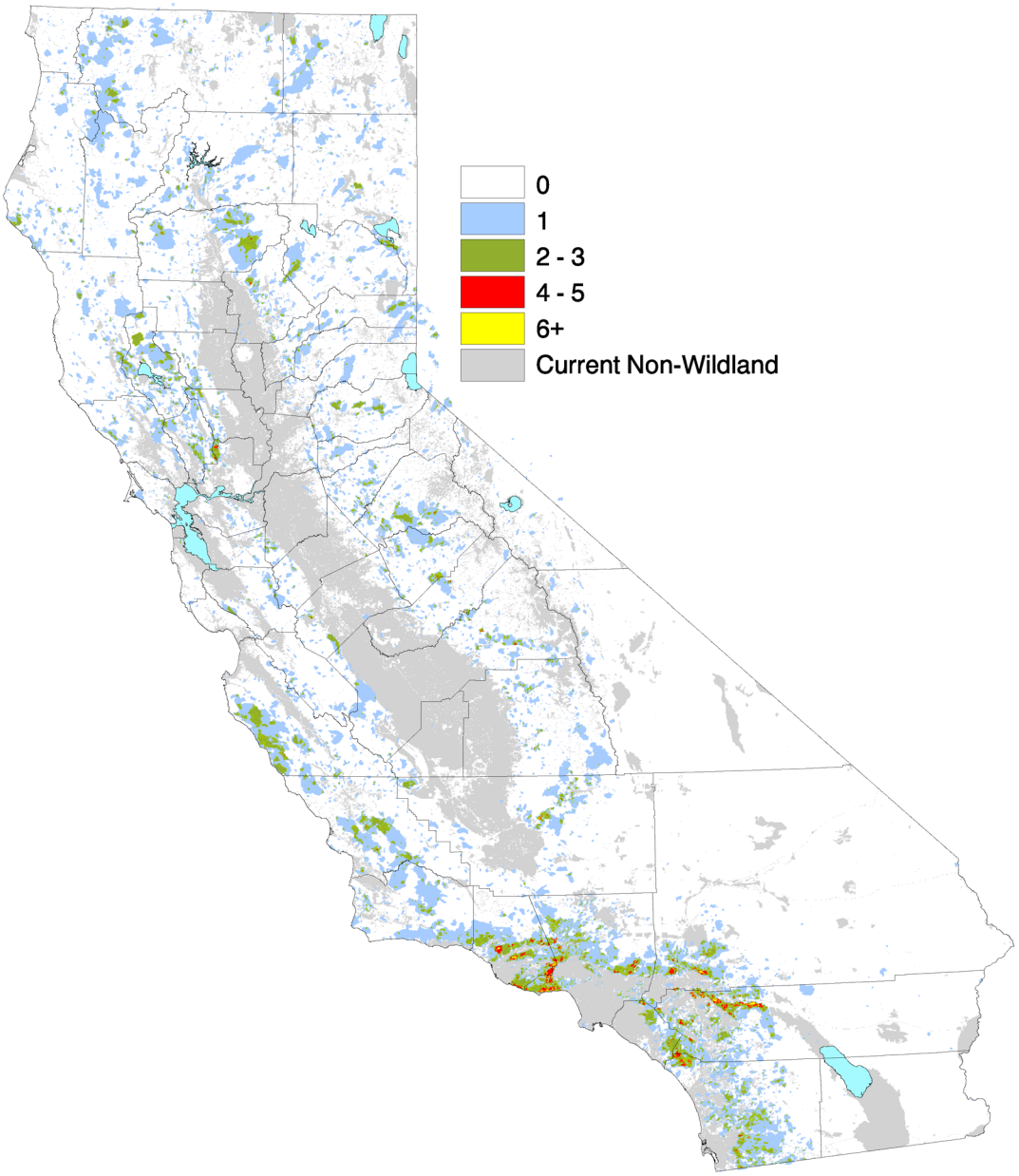
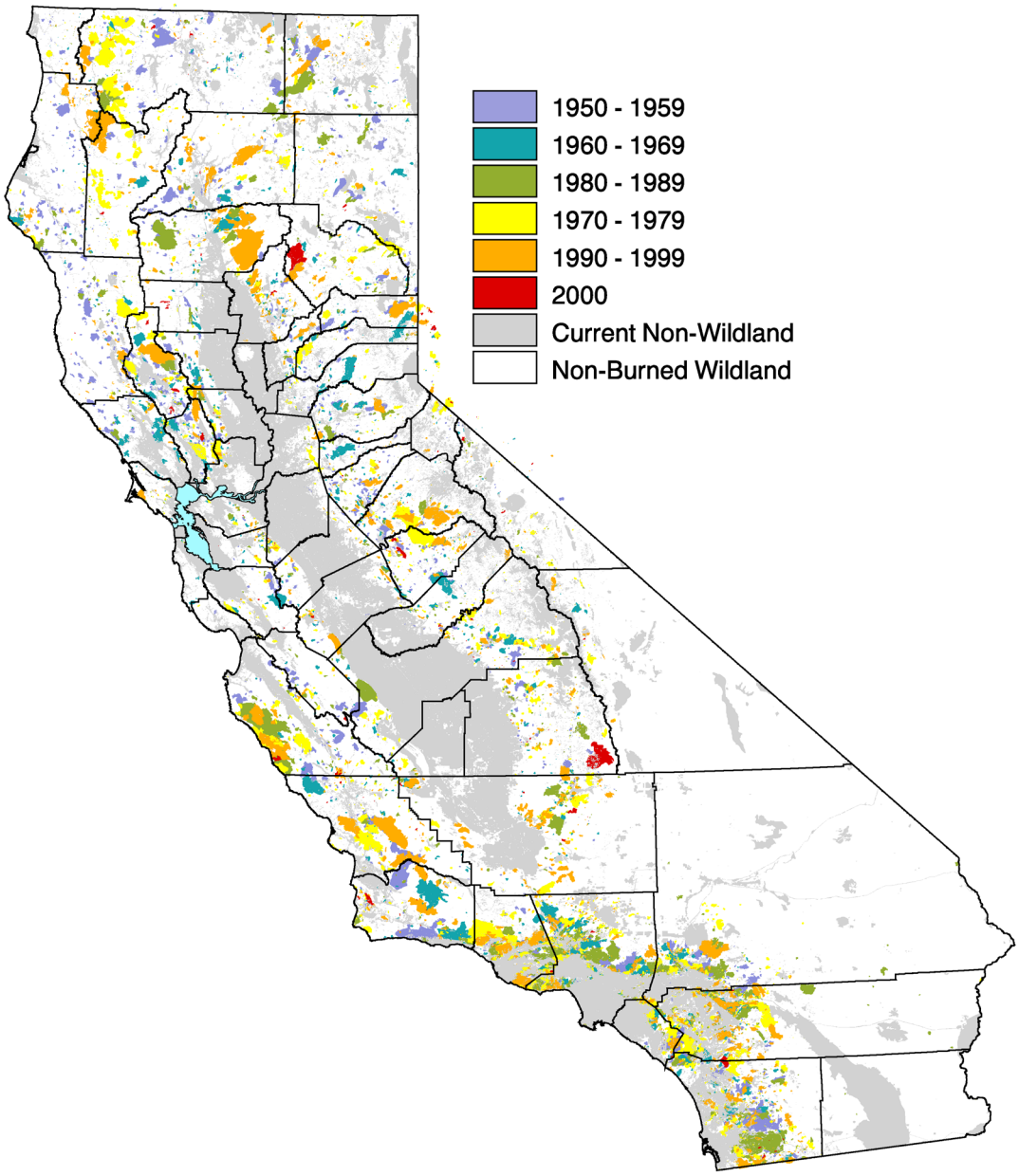
Despite the significant reduction in fire seen in the modern era, fire is still a significant force on the landscape. Figure 2 shows the number of times a given area has burned in large fires since 1950. Another representation of the same data shows the decade in which areas last burned (see Figure 3). The data represented in these maps (called "fire perimeter data" because the actual shapes of the fires are shown) is a conservative estimate of total modern-era fire occurrence because it is limited to fires that burned at least 300 acres, and many areas are not accounted for due to limited reporting of wildfires. See Fire Perimeter Data and Methods.

Figure 2. Number of times area burned in large fires since 1950




*Source: FRAP, 2002b*

Figure 3. Last decade area burned by large wildfire since 1950




*Source: FRAP, 2002b*

## Trends in annual area burned

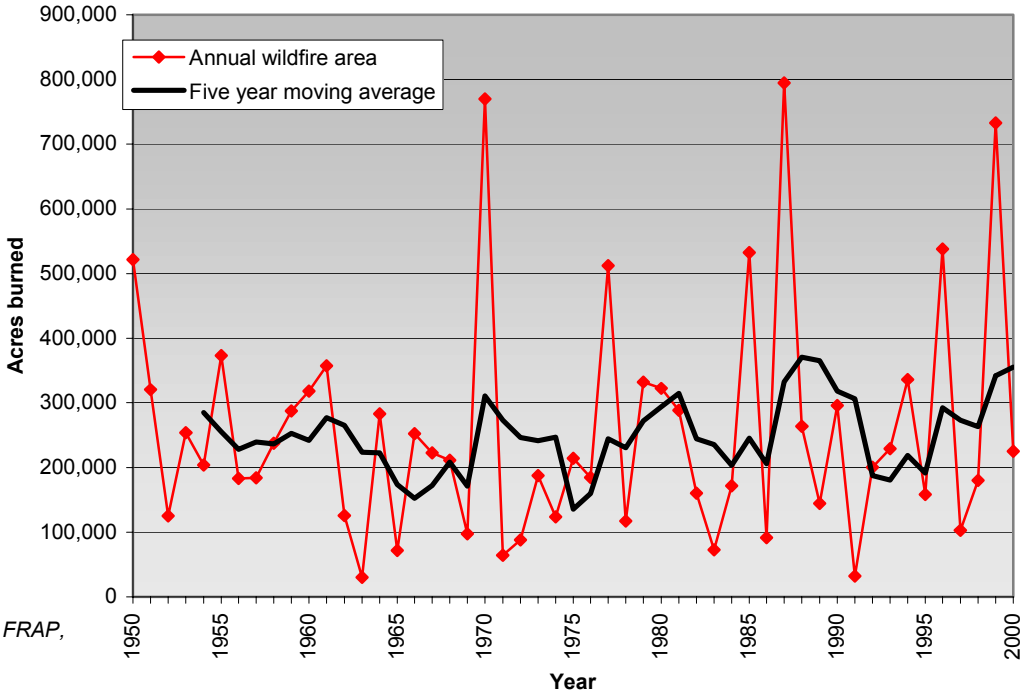
In general, the pattern of annual area burned over the last 50 years has been highly variable. When viewed Statewide, the temporal variation masks any possible trends in total acreage (see Figure 4). The high variation in year to year totals would appear to largely be related to climate, where periods of significant drought are associated with large area burned years (Swetnam, 1993; Davis and Michaelsen, 1995; McKelvey and Busse, 1996; Moritz, 1997).

*McNally Fire, Sequoia National Forest, Tulare County, California. Date of fire origin: July 21, 2002. Photo courtesy USFS.*

The influence of global climate change on future fire regimes is uncertain. However, changes in the distribution of moisture and temperature regimes will cause changes both to fuel characteristics and to burning conditions, and have been hypothesized to portend significant changes to both fire frequency and effects (Lenihan et al., 1998, Torn et al., 1998). Current research is looking at linking global circulation models of precipitation and temperature to metrics of fire potential such as drought indices (Westerling, 2002). Additional research is focusing on ignition and fire growth models (Miller and Urban, 1999; Lenihan et al., 1998) to predict fire trends resulting from large-scale climate changes. The apparent increase in frequency of large fire years after 1970 may indicate interactions between climate change and increased fuel accumulations. However, a clear connection between regional fire totals and changes in fuels has not been demonstrated in the literature.

***The increase in large fires after 1970 may indicate interactions between climate change and increased fuel accumulations.***

Figure 4. Annual area burned in California, 1950-2000



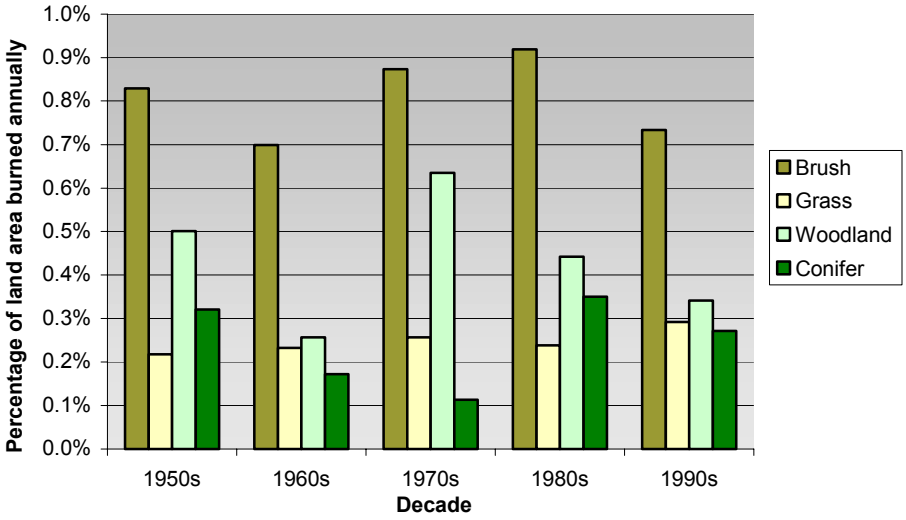

*Source: FRAP, 2002a*

## Annual percent of area burned by vegetation type

Trends in wildfire across vegetation types indicate the strong influence of vegetation characteristics on the percent of area burned over time. Using the decadal averages of annual percentage of land area burned in each broad vegetation life form, it is clear that brushlands burn most frequently. The percentage has consistently remained between 0.73 and 0.92 percent over the last five decades (see Figure 5). Grasslands burn about one-third as frequently as brushlands, and these percentages have also been relatively static over time. This lower percentage in grasslands may be due to impacts of grazing, limiting fuel abundance, and continuity. In contrast, conifer and woodland types have shown significant variation when viewed over time.

***Brushlands burn significantly more frequently than other vegetation types.***

Figure 5. Percentage of area burned by decade and vegetation life form, 1950-1999



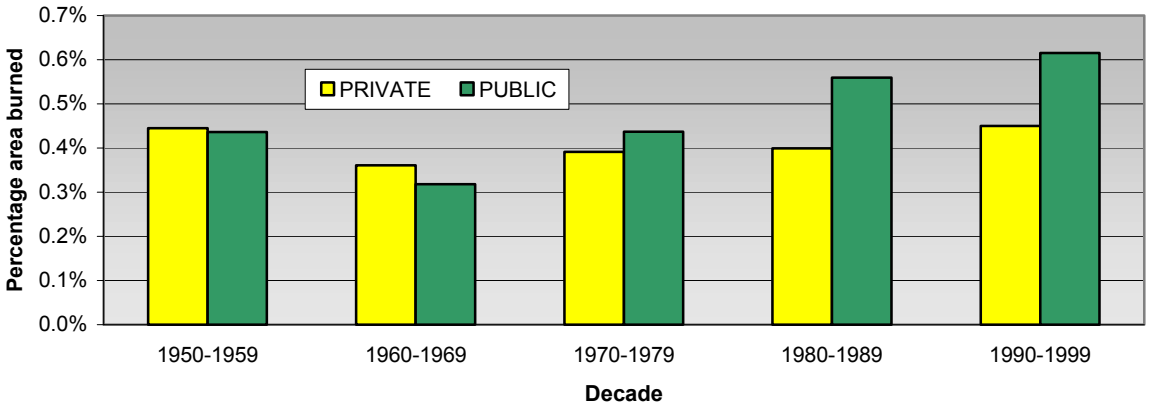

*Source: FRAP, 2002a*

## Annual percentage area burned by ownership

***Lands in public ownership began burning more frequently than private lands around***

When all vegetation types are combined and annual percentages of area burned are compared between broad ownership groups, lands in public ownership began burning more frequently than private lands around 1970. This trend has continued to the present, with the most recent decade showing almost twice the percentage as that seen in the 1970s (see Figure 6). In contrast, area burned on private lands has been relatively constant, ranging from a low of 0.36 percent in the 1960s to a high of 0.47 percent in the 1950s.

Figure 6. Percent of area burned by decade and ownership




*Source: FRAP, 2002a*

A detailed discussion of methods, findings, and trends across ownerships and vegetation can be found in the FRAP analysis Area Burned by Vegetation Type and Ownership (FRAP, 2002a).